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in connection with Application No. 2003904336 for a patent by MEDCARE
SYSTEMS PTY LTD as filed on 15 August 2003.

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An Automated Personal Alarm Monitor

What is claimed is:

1. A method for monitoring a person's movement to detect an inability to rise due to a fall through using a triaxial accelerometer included in a personal monitoring system that consists of a receiver unit and a personal monitoring device, which communicates with the receiver units by means of wireless communication, and which is configured to be carried on the person and containing the triaxial accelerometer, comprising the steps of:

   (a) sampling an output from the triaxial accelerometer indicative of body acceleration and body angle;

   (b) comparing the magnitude of the acceleration vector to an acceleration magnitude threshold for a period equal to a time duration threshold to determine the presence of an abnormal acceleration indicative of a fall;

   (c) identifying a body state indicative of lying by comparing the body angle to a threshold value;

   (d) determining the subsequent absence of movement by comparing the magnitude of the acceleration vector to a second acceleration magnitude threshold.

2. A method as in claim 1, further comprising the step of signaling a fall via a communications network when a severe fall has taken place.

3. A method for monitoring a person's movement to detect an inability to rise due to a collapse or other adverse event through using a triaxial accelerometer included in a personal monitoring system that consists of a receiver unit and a personal monitoring device, which communicates with the receiver units by means of wireless communication, and which is configured to be carried on the person and containing the triaxial accelerometer, comprising the steps of:

   (a) sampling an output from the triaxial accelerometer indicative of body acceleration and body angle;

   (b) comparing the magnitude of the acceleration vector to an acceleration magnitude threshold for a period equal to a time duration threshold to determine the absence of a normal amount of movement;

4. A method as in claim 3, further comprising the step of signaling the extended absence of movement via a communications network when no movement has occurred for the specified period.

5. A method for longitudinal tracking of clinically significant parameters to detect early changes in functional status including but not limited to the onset of near falls and stumbles. Clinically significant parameters are extracted from the data obtained from the triaxial accelerometer and stored in a database. Deviations from the statistical normal values for each parameter are flagged. An alert is generated each time that a deviation is flagged. Long term trends in the parameters are also flagged. When a trend is detected in a parameter that exceeds a change threshold an alert is generated.

DESCRIPTION

TECHNICAL FIELD

This invention relates generally to the field of personal alarm monitors for clients, and more particularly to an improved monitor for detecting and providing an alarm in case of inability to rise due to a fall, collapse or other adverse event.

BACKGROUND ART

The population is ageing (1, 2). The population of those aged 65 years and over is projected to rise from around 12% now to 24% by 2051 (3).

Falls are one of the greatest risks facing this group. In the over 65 age group, accidents are the fifth highest cause of death (4), and approximately two thirds of accidents are falls (5). Falls account for 54% of all injury-related hospital admissions in this group (6).

Falls and collapse are associated with functional decline, leading to disability, dependence and nursing home placement (7-10), even in cases where the fall did not cause injury (11, 12). Up to half of all older people who fall or collapse without suffering injuries are unable to get up without assistance.

In the case of the elderly or infirm person living alone, an inability to rise can lead to serious consequences of extreme distress, muscle damage, pneumonia, pressure sores, dehydration, hypothermia and mortality (13, 14). Many such people become afraid and so restrict their daily activities and exercise, which in turn leads to a further reduction in health and wellbeing (9, 11).

Personal alarm systems provide persons with an emergency button. However this technology is rendered ineffective if the person is unable to press the button (due to unconsciousness, injury or immobility). There are also issues with useability and robustness of these technologies.

Currently, some prior art methods disclose falls monitoring by wearable devices. For example, US Patent 6,433,690 by Petelenz *et al.* describes a falls monitoring method and device for use in the elderly or disabled. We describe a similar embodiment but our method identifies an inability to rise, as well as a means of detecting falls, collapse or other adverse events and automatically generate an emergency alarm signal.

US Patent 6,501,386 by Lehrman *et al.* discloses a system within a communication device for evaluating movement of a body in a manner similar to that reported in published literature. Our invention makes use of a similar communications device for monitoring accelerations but a method is embodied that can be used to identify an inability to rise.

Other methodologies have been developed for the detection of falls (U.S. Pat. Nos. 4,829,285, 5,477,211, 5,554,975, and 5,751,214) although these disclosures make use of mechanical level switches and not accelerometers.

SUMMARY OF THE INVENTION

This invention provides a method for detecting a person's inability to rise after a fall, collapse or other adverse event using a triaxial accelerometer included in a personal wearable ambulatory monitoring device. The first part of the procedure involves the detection of an inability to rise caused by a fall event. The first step in the method is sampling an output from the triaxial accelerometer that is indicative of body acceleration and body angle. The next step is to determine whether a fall has taken place by comparing the magnitude of the acceleration vector to an acceleration magnitude threshold for a period equal to a time duration threshold to determine the presence of an abnormal acceleration. If an abnormal acceleration is detected then the body angle is compared to a threshold value to identify a body state indicative of lying. A subsequent absence of movement is detected by comparing the magnitude of the acceleration vector to a second acceleration magnitude threshold.

The second part of the procedure involves the detection of an inability to rise due to collapse or other adverse event. The first step in the method is sampling an output from the triaxial accelerometer that is indicative of body acceleration and body angle. The next step is to identify an inability to rise by comparing the magnitude of the acceleration vector to an acceleration magnitude threshold for a period equal to a time duration threshold to determine the absence of a normal amount of movement.

Additional features and advantages of the invention will be set forth in the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate by way of example, the features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a wearable ambulatory monitoring device;

FIG. 2 is a flow diagram of the logic for an embodiment the inability to rise detection method;

DETAILED DESCRIPTION

The following description refers to an exemplary embodiment of the invention. It will be understood that no limitation of the scope is thereby intended and that those skilled in the art could make various changes, substitutions and alterations herein without departing from the scope of the invention in its broadest form.

1. The person wears a triaxial accelerometer on the waist.

2. Data are sampled from the triaxial accelerometer by a microprocessor in the monitoring device and stored in a buffer in the monitoring device.

3. The data are processed according to process 1 and process 2 below.

PROCESS 1 – detection of an inability to rise precipitated by a fall event

4. Data are converted from Cartesian to polar coordinates.

5. The value of the polar magnitude vector is compared to a magnitude threshold (1.8 g).

6. If the value of the polar magnitude is less than the value of the magnitude threshold, then continue monitoring from the start of the process.

7. If the value of the polar magnitude exceeds the value of the magnitude threshold, then continue monitoring the next samples.

8. If the value of the polar magnitude does not continuously exceed the value of the magnitude threshold for a period of time that exceeds a time threshold then continue monitoring from the start of the process.

9. If the value of the polar magnitude continuously exceeds the value of the magnitude threshold for a period of time that exceeds a time threshold then an abnormally large acceleration has been identified.

10. Measure the body angle immediately following the abnormally large acceleration event.

11. Compare the body angle to a threshold angle that is indicative of a lying state

12. If the body angle does not exceed the lying state threshold then the abnormally large acceleration event was deemed to have been a stumble or knock, but not a fall. Log the event and continue monitoring the next sample from step 4.

13. If the body angle does exceed the lying state threshold then the abnormally large acceleration event was deemed to have been a fall. Wait 60 s.

14. Measure the body angle again.

15. Compare the new body angle to the lying state threshold.

16. If the body angle does not exceed the lying state threshold then the person was able to rise unaided. Raise an alert. Continue monitoring from the start of the process.

17. If the body angle does exceed the lying state threshold then the person was not able to rise unaided. Raise an alarm.

PROCESS 2 – detection of an inability to rise other than due to a fall event

18. The root mean square value of the signal is computed every minute.

19. The root mean square is compared to a threshold value.

20. If the root mean square exceeds the value of the threshold then continue monitoring from the start of the process.

21. If the root mean square is less than the threshold value then continue monitoring the next samples for a threshold period of time (6 hours).

22. If the value of the root mean square exceeds the threshold value at any time during the 6 hour period then continue monitoring from step 20.

23. If the value of the root mean square does not exceed the threshold value at any time during the 6 hour period then an extended absence of movement indicative of an inability to rise has been identified.

24. Raise an alarm.

Alerts and alarms are raised in the following manner:

25. Wireless communications are established between the wearable ambulatory monitor and a base-station that is able to connect to the telephone line.

26. The event is recorded and an electronic message is sent to a monitoring call centre. In the event of an alert, no further action is taken.

27. In the event of an alarm, the telephone line is opened by the base-station. One of three pre-programmed numbers is dialled. Voice communications are established between the monitoring call centre and the person.

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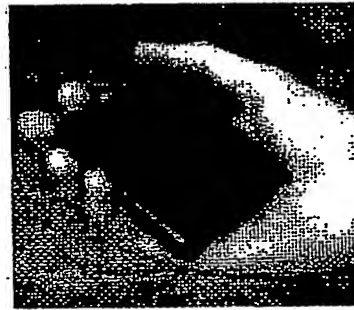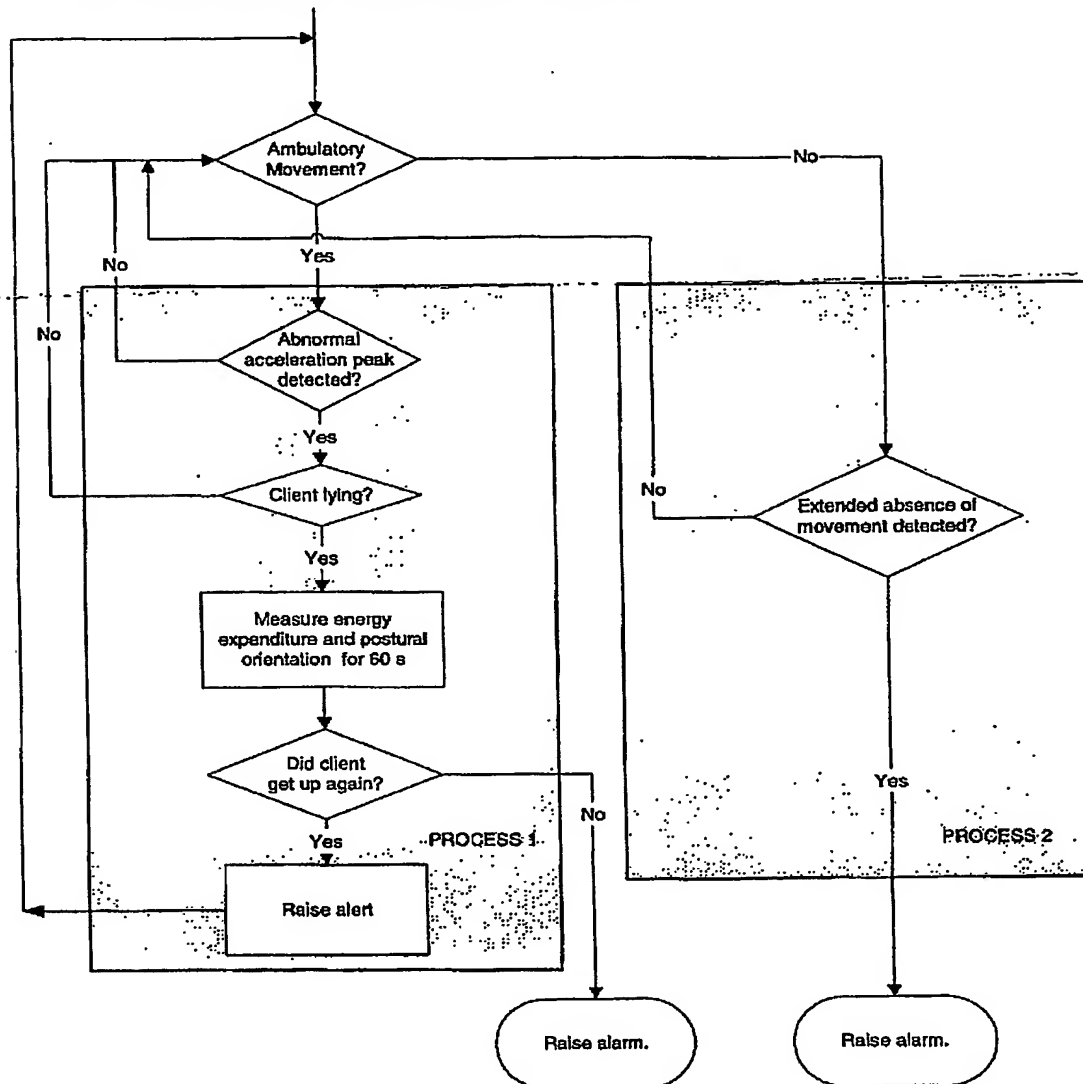
FIG. 1

FIG 2.

DATA PROCESSING FLOWCHART FOR AUTOMATED FALLS
DETECTION USING A TRIAXIAL ACCELEROMETER

Ambulatory
Movement? — No

Yes | No | No

Abnormal
acceleration peak
detected?

Yes

Client lying?

Yes

Measure energy
expenditure and postural
orientation for 60 s

Did client
get up again? — No

Yes   PROCESS 1

Raise alert

Extended absence of
movement detected?

No

Yes

PROCESS 2

Raise alarm.

Raise alarm.

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